cal problems is well set forth in Meyer's "Anleitung," but the criterion for the rejection of abnormal observations is not mentioned by him. There are perhaps but few opportunities for its application in meteorology, but its propriety seems very evident in case of such excessive rains as at Cherrapoonjee, India, and in our American "cloud-bursts." The further study of this subject is of interest.

PROTECTION FROM FROST.

In a recent number of the WEATHER REVIEW (November, 1894, page 463) some suggestions are given as to methods of protecting tender vegetation from injury by severe frost. In that article the sprinkling of the plant and the ground with water is especially mentioned as a preventive. On this subject Prof. R. C. Kedzie, of the Michigan State Agricultural College, at Lansing (as quoted in the August Bulletin of the Michigan State Weather Service), says:

The great regulator of temperature is water. Water in becoming warmed takes up a large amount of heat and gives out the same amount of heat in cooling. Evaporation is a powerful cooling process and condensation of water vapor is an equally powerful heating process. The vapor of water in the atmosphere may control excessive changes of temperature in two ways:

1. By condensing into water it liberates enough heat to raise through one degree the temperature of a thousand times the amount of water condensed, and, hence, powerfully arrests the fall of temperature by giving out heat. In this way the beneficent dew becomes a warming-pan for our chilling fields.

2. The vapor of water in the air (and the clouds also) prevents the escape of heat by radiation from the soil and consequent cooling of the ground during the night. But for the vapor of water in the air we should have a frost every night in the year. The removal for a single summer night of the aqueous vapor which covers England, would be attended by the destruction of every plant which a freezing temperature could kill.—Tyndal on Heat, p. 405.

If the farmer is forewarned of the approach of a still frost he may do something to avert the calamity. The conservative influence of watery vapor is the most hopeful means of protection, and sometimes trivial causes of this class will produce surprising results. The old plan of a tub of water under the fruit tree, and a rope reaching from the tub into the branches, may serve a useful purpose. The evaporation from the water in the tub and of the water carried up by capillary action in the rope may spread the protecting folds of the water blanket over the tree. Such appliances, while of some use for a small garden, would be futile for a farm.

If the hoed crops of the farm are cultivated with reference to securing a constant supply of moisture in the upper soil, to draw by capillary action of the soil upon the reservoir of water in the subsoil, and at the same time to keep the surface soil in such condition as to prevent the too rapid dissipation of soil moisture, the fields may be saved from frost by a covering as impalpable as air but as effectual as eider down. Here is a conservatism of highest importance for both farmer and fruit grower. On the night of September 16, 1868, the Indian corn in Michigan was almost entirely killed by frost, only a few fields along the banks of rivers or the borders of lakes being spared. In these fields the corn stalks the next morning were dripping with dew. The evaporation from river or lake during this dry time (only one-eighth inch of rain in two weeks) had moistened the air in the vicinity and staved off the frost. Away from bodies of water the air was very dry and the dew point low. At the Agricultural College the temperature in the open air at 2 p. m., September 16, was 54°, the wet bulb marked 44°, and the temperature of dew-point was 31°. During the night the temperature sank to 24°, and a black frost was the result. If the air over the whole State had been as moist as it was along those rivers and lakes, a heavy dew would have fallen everywhere and the corn crop would have been saved.

This immunity from frost afforded by a moist atmosphere is a matter of great importance. I once read in a newspaper of the experience of a farmer who feared a frost on his growing corn, and who cultivated the field, stirring up a moister soil, and thus promoting evaporation, with this result, a heavy dew and a rescued crop, while neighboring fields of corn were cut by frost.

Ten years ago some beautiful beds of coleus were near my house. Early in October there were threatenings of frost. Every evening the beds were thoroughly wet down with cold water, and the tender coleus plants escaped frost while other plants near by were killed. At this time I found my neighbor one evening putting blankets over his grapevine to save the fruit from frost. I advised him to take away his woolen blankets, and put on the water blanket by a thorough drenching with water. This was done and the grapes saved.

This use of water to guard tender plants from frost has frequently been tried at the college, and generally with good results. Strawberries and grapes in blossom may be saved in this way and with little trouble, if a good supply of water and a sprinkling hose are available. The quick-witted farmer or gardener will find many ways of using water for this purpose. With irrigation we might defy frost during the growing season.

When water is not available for such purpose advantage may be taken of fire to ward off frosts; not by the hope of warming the body of air over a field, but by forming a canopy of smoke over the field to prevent the escape of heat by radiation from the ground. In France the vineyards at the time of blossoming of the grape vines are often preserved in this way. Any material that will form a dense smoke, like coal tar, is preferred for this purpose. A smudge is better than a bright fire because it makes more smoke.

* * * * * * *

The use of water in case of frost may be found beneficial even after the frost has occurred. Several cases are known where, after the severe frosts which occurred in May, 1895, several acres of grapes were saved by a thorough drenching with water early in the morning after they had been quite severely bitten by frost.

The following paragraph from the Orange Judd Farmer, August 31, 1895, is worth repeating in this connection:

Protection against frosts is a vital matter to fruit growers and truckers, whose season's labor and investment may be wiped out by a single destructive frost. The more valuable the crop and the greater the risk of frost the more effort and expense may be safely put into means of protecting against frosts. A famous California orange grove is equipped with a system of iron pipes, through which water is conducted to nozzles at frequent intervals, the idea being that the spray will ward off light frosts. Barrels of tar and rubbish in different parts of the orchard are available for making a smudge of smoke, which is the most practicable means yet devised. In the case of a freeze such as visited California two years ago and Florida last winter, or a real hard frost in other sections, neither of these methods is of much avail. Smoke is good against all light frosts and is easily obtained. Strawy manure, leaves, rubbish, etc., should be piled in the lowest places and about the sides of the field and covered with hay caps or ducking (previously painted with two coats of linseed oil and dried), so as to be always dry. Have a barrel of kerosene oil handy, some cans and torches. When the frosts threaten, set a night watch to inspect thermometers placed on stakes in various parts of the field, especially in the most exposed places. If the mercury drops to 35° by 1 or 2 a. m., it is likely to mean a frost of more or less severity before sunrise. Then call up the folks, light the torches, and let each person take torch and oil can (previously filled) and set fire to the row of rubbish heaps previously assigned him. If the wind blows the smoke away from the field, carry some rubbish over to the windward side, so that the smoke will be blown to instead of from the field. If the frost does not come, no expense worth mentioning has been incurred, as the piles can be scattered and plowed under for manure or burned, the ashes making excellent fertilizer. No prudent person thinks of leaving his buildings uninsured against fire. Certainly it is just as important to insure against frosts, so far as it can be done by such simple means as smoke coverings, or water. We wish all who have had experience in this matter would send it for publication.

Mr. E. P. Powell, a successful and brainy horticulturist in western New York, writes:

"The very best preventive against frost is not fires, but thorough spraying with water during the evening and night. When this can be done, we can overcome the danger from a fall of two or three degrees. This will often save our whole crop. This last spring I lost my grapes by a margin of not more than two degrees, but on a preceding night anticipated the frost by deluging the trellises with water. Of course bonfires may also be used. I anticipate we shall be compelled to adopt irrigation in all the Eastern States."

HOW DO RAINS AND WINDS SPREAD EPIDEMICS?

Professor Charles Mayer, as quoted from the Tennessee Journal of Meteorology, says:

Occasionally epidemic diseases seem to have been spread by clouds and the rain from them. The best authenticated case is that of a plague epidemic in the fifteenth century, which broke out most violently in a Swiss town immediately after a cloud, coming from an infected but distant region, discharged its rain upon that town.

[NOTE.—The relations of the weather to the spread of epidemics are still involved in great obscurity. Without going back to the fifteenth century, there was an excellent opportunity to investigate the subject in 1889–'90, when the grip spread over the whole civilized world. Its progress was so regular that for a long time there was a general belief that the active germs of influenza were carried as dust in the air by the winds, or perhaps by the upper currents. This idea

was dissipated by several memoirs that established the fact that the wind and weather were entirely subordinate factors and that the spread of the disease followed the lines of travel, especially the principal steamboat and railroad routes, and that, therefore, the germs were carried by diseased individuals or by articles that had been used by or had come in contact with them, and not by the winds. Of course the wind, in the narrow sense, may have carried the germs a few feet or rods from one individual to another, but not for distances of many miles. Several epidemics, such as the yellow fever, smallpox, and cholera, have been traced back to the direct importation of their contagia (whether animate or inanimate) by human agencies. Furthermore, it appears probable, from experimental data, that few disease germs can maintain their vitality more than a few hours when freely exposed to the air and sunshine, as would probably be the case if they were carried in the atmosphere as minute particles of dust. Therefore we think it probable that the winds and the rain must not be considered as the means by which diseases are spread between places that are any considerable distance apart. The limit to which living germs can be carried in the free air is not yet accurately known, but is believed to be quite small. The upper currents of air carried the vapor dust from Krakatoa, in 1883–'84, over the whole Northern Hemisphere, but many months were required to do this, and what little we know of the life history of disease germs teaches that they could not survive the sunshine, the dryness, and, perhaps, the cold of the upper currents. This is not to deny that the winds and the ocean currents can carry the coarser seeds of plants and fungi for many miles without injury; but the bacterial disease germs have a far more delicate organism than those seeds, and what would seem to be an allowable analogy between the transportation of seeds and germs fails when applied on a large scale. The wind may carry the germs to a great distance in the free air, but probably will kill them in so doing; local breezes may carry living germs a few hundred feet, but the diseased man or the convalescent, or the clothing and articles used by these, or the water we drink, or the food we eat, may carry them hundreds and thousands of miles. In the particular case of the spread of the epizootic and influenza epidemics of 1872–'73 among horses and cattle it was shown that they spread against the wind, or when there was a calm, quite as often as they spread with the wind.]

The following extract shows the result of an extensive investigation by the medical department of the Prussian army into the spread of the grip epidemic of 1889–90. It illustrates what we have above said and shows that we must not exaggerate the influence of the lower winds or the upper currents:

If we now collect together the results of experience as to the spread of the grip in the German army, we find that the view still holds good which prevailed at the beginning of the epidemic to the effect that the influenza is a disease that owes its origin to certain miasmatic external causes. On the other hand there does not appear to be any sure evidence of the influence of weather, climate, wind, or soil, or the season of the year. To the contrary the number of those cases in which the spread and the mode of spreading of the grip is to be attributed to human intercourse, is considerably increased by the experience of the last epidemic. It is not yet clear whether in this intercourse there is a direct carriage of the infectious material from person to person, or whether the infection is carried by the intervention of inanimate objects through the air. We are still ignorant of the real germ that causes the disease. A correspondent from Bavaria gives the following example which leads him to believe that inanimate substances may house the real germs of the disease and carry them far away: The medical officer of the garrison at Germersheim at a time when as yet not a single case of grip had occurred at that place, received a package from a place in Russia at which the disease prevailed severely. A short time after opening this package he fell sick of the grip, and soon after also his whole family. If it should be further demonstrated that dead substances can thus contribute to the spread of the disease germs, then, perhaps in this way we shall explain the appearance of the disease upon ships on the high seas. The germs attached to the cargo carried by a ship can, by spreading among the seamen, give rise to a violent, sudden outbreak of the grip.

Those interested in studying the distribution of disease and in defending the general atmosphere from calumny will find a mass of information in the Handbook of Geographical and Historical Pathology by Dr. August Hirsch, translated and published by the new Sydenham Society, London, 1883. The data there given show that not only influenza but nearly every other form of epidemic has a secondary dependence upon favorable weather. Some diseases that are characteristic of tropical climates have been known to break out in midwinter when the ground is frozen and covered with snow; these occurrences depended upon the habits of the people, the temperature and cleanliness of their houses, the food they ate, and the water they drank, rather than on any special meteorological conditions.

The "climate" of the sanitarian considers not merely the sunlight, temperature, moisture, and wind of the meteorologist, but many other factors that constitute the environment of man and have a bearing on health and disease.

DO THUNDERSTORMS ADVANCE AGAINST THE WIND?

The note from Mr. Hicks, published in the MONTHLY WEATHER REVIEW for April, page 131, has called forth the following letter from Mr. C. A. Perdue, voluntary observer, Beloit, Kans. (W. 98° 05′, N. 39° 30′, 200 miles west of the Missouri River), and the editor will be glad to obtain still other notes on this point.

In the report for April, which I have just received, I notice the statement of Mr. E. D. Hicks, observer at Marceline, Mo., of which I have heretofore seen no notice in print. This fact I have frequently observed since my residence here and can confirm his observation. It is probable that the same phenomenon will be shown to occur over all those treeless plains so much above sea level when further observations are made.

THE CAUSE OF THE LOW TEMPERATURES FOR AUGUST.

Mr. George N. Salisbury, Director of the Washington State Weather Service, writes in the August REVIEW, as follows:

This was an excessively dry month in all sections of the State. Practically no rain occurred until the rainy period, which began in the northwestern part of the State on the 19th, and ended in the eastern part on the 21st. Prior to this the drought had been of six weeks' continuance. West of the mountains the average rainfall was a trifle more than last year, but much less than that of any other August on record. East of the mountains it was a trifle less than last year, and less than any August on record. It was the coolest August of which there was any record here, notwithstanding the fact that there was so little rain and cloudiness. This is probably accounted for by the fact that on many days that were otherwise clear the sun was almost entirely obscured by excessive smoke from forest fires, which extended over a great part of the eastern as well as the entire western section of the State.

[NOTE.—The interesting suggestion here made has led the editor to compare the mean maxima for August, 1895, with those for August, 1894, and to do the same, also, for the monthly mean of the minima. The details, as given in the following tables for the eastern and western portions of the State, show that, as compared with 1894, the average and maximum temperatures of 1895 were, indeed, lower. The lowering of the maxima might be attributed to the direct effect of the absorption of solar rays by the smoke, but as the minimum temperatures were also lower, and that, too, even more so than the maxima, it becomes evident that the obscuration of the sunlight by the smoke is not the only, nor indeed the principal cause, of the average low temperature. The data for surrounding States show that the temperature was below the normal throughout the Pacific Coast, the Plateau Region, Montana, and the Canadian Provinces of Alberta, Saskatchewan, and Manitoba. Over the northwest part of this region the pressures were above the normal, and over all of it the rainfall was below normal. Everywhere, moreover, the lowest minima on record were reported.